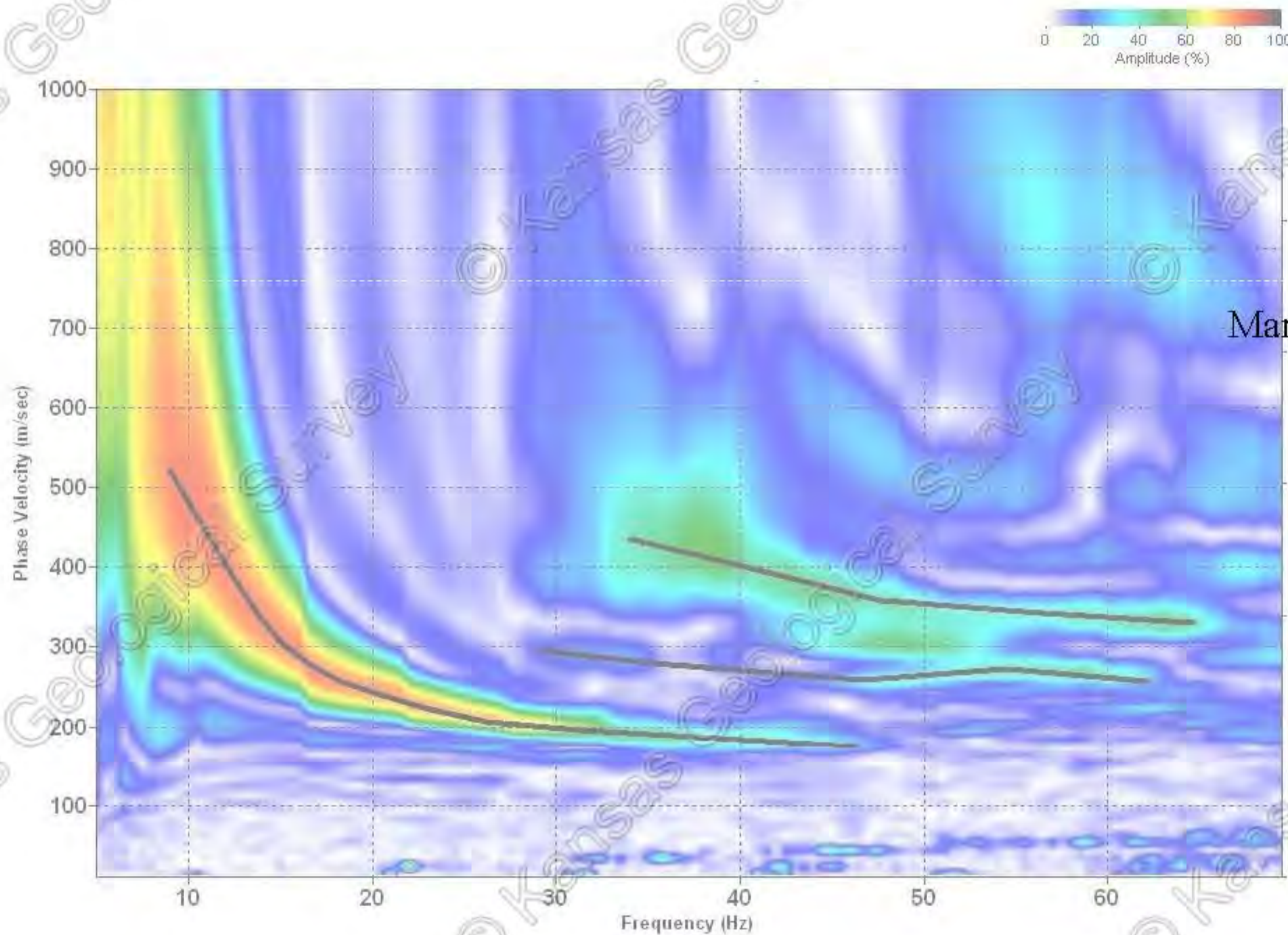


SurfSeis[®] **Multimode MASW**

Seismic Processing Software
for use with
Microsoft[®] Windows[™]

(Supplementary) User's Manual v 3.05



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Table of Contents

Introduction

Chapter 1: Menus

Chapter 2: Multimode Surface Wave

2.1 Multimode dispersion-curve picking

2.2 Multimode dispersion-curve inversion

Chapter 3: Hardware License (HL) protection (USB dongle)

References

Introduction

The purpose of this manual is to present the new features in SurfSeis 3.0. This manual is intended to be used in conjunction with the manuals from previous versions of SurfSeis 1.5, and 2.05. All the manual files are in the “Manual” subfolder of the SurfSeis 3.0 application folder (e.g., C:\SurfSeis30\Manual). We understand the need for a new manual that adequately reflects the current state of the software in detail with all its forms and options. The development of such a manual is on our ‘to-do’ list. Thus, the purpose of this SurfSeis3 supplementary users manual short version is to provide the most necessary information that will allow our users to use this new version of our software.

The multichannel analysis of surface waves (MASW) method has been under development for more than a decade and we at the Kansas Geological Survey (KGS) have included new features in our software that reflect the most recent research. The following list includes the most important new features in SurfSeis 3.0:

- Fundamental and higher mode observation
- Inversion using higher modes – greater resolution
- Inversion using a priori density information
- New menus and friendly dialogs complementing existing interface; smoother operation; faster code
- Hardware key (USB dongle)
- Improved compatibility with other KGS seismic software (i.e., WinSeis, SeisUtil, SeisModeler)

This manual has three main sections, which reflect the types of changes in the software. Chapter 1 presents the changes in the interface – new menus and forms (windows). Chapter 2 discusses the most recent research incorporated in the software – multimode surface-wave dispersion-curves estimation and inversion. Chapter 3 provides information about our new software licensing/protection method, which is accomplished using a USB key (dongle). The new software may be installed on multiple machines, but it will run only on a machine where the dongle is installed.

Many of the bugs existing in SurfSeis 2.05 version have been fixed, as suggested by users. However, SurfSeis 3 was developed to allow the use of an expanded data set structure that could be used for multimode dispersion-curve picking and inversion. As a result, many parts of the software had to be modified or rewritten to be able to use the new data structure. Additional work was also done to provide backward compatibility with the data structures from previous versions of the SurfSeis software (i.e., versions 2.05 and earlier). We hope that we’ve succeeded in our goals but we also realize that although we’ve tested many possibilities there could be some functionality that needs to be adjusted or can be improved. We rely on our users for feedback and suggestions and we, the KGS staff, sincerely appreciate your comments and help in improving the software.

Chapter 1 Menus

Efforts were made with SurfSeis 3 to provide friendlier software. Menus were modified in a manner that preserved the existing button-driven interface for backward compatibility as well as provide more options to our users. Equivalent functionality can be accomplished by the old button-driven interface and the new options.

The main window now is not maximized (Figure 1). This offers more flexibility, especially with the widespread use of widescreen monitors (with a 16:9 width-to-height aspect ratio). As well, you may find that it is more convenient to run SurfSeis 3 with an aspect ratio of approximately 4:3. The graphics in this manual use a smaller main window to save space and for convenience.

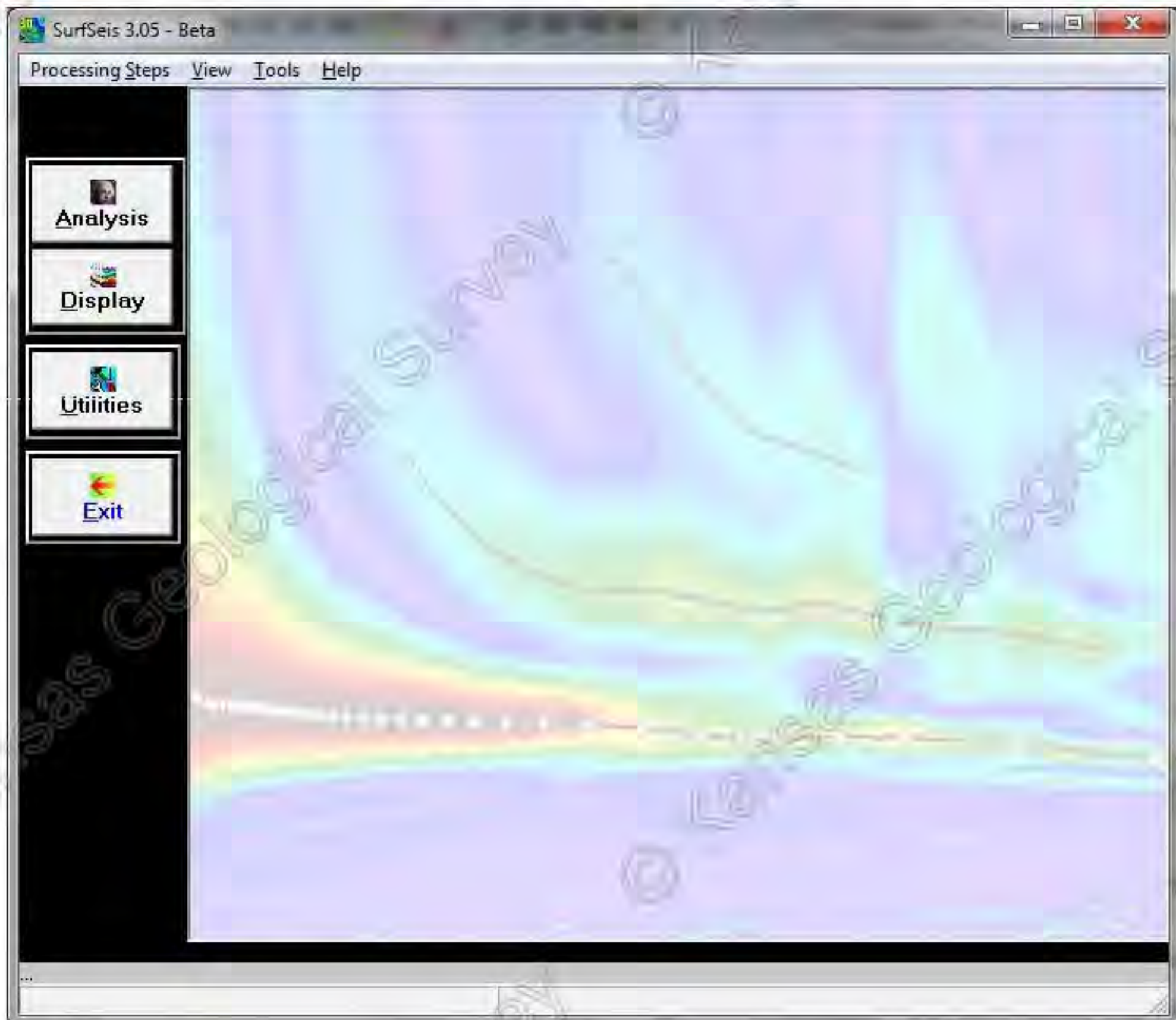


Figure 1. Main window display.

Each menu option can be accessed using a single or a series of clicks on the available large buttons (e.g., 'Analysis', 'Display', 'Utilities', and 'Exit') located on the left sidebar on the main window of the software (Figure 1). For each presented menu option there is a corresponding

equivalent set of left button mouse click, and those are given in parenthesis. As well, we provide shortcuts, i.e., letter or number keys, sometimes in combination with the 'Ctrl' or 'Alt' keyboard keys, which can also be used to access the menus quicker.

In the “**Processing Steps**” menu item (Figure 2) we tried to group all the steps of the natural processing flow: data preparation (preprocessing), dispersion-curve imaging and estimation, and dispersion-curve inversion.

The data preparation steps include the menu options:

“**SEG2->KGS Conversion**” (“Utility” button, “Import SEG-2 Data” [former ‘Format’ tab]), and
“**Geometry Assignment**” (“Utility” button, “Geometry” tab [former ‘Field Setup’ tab])

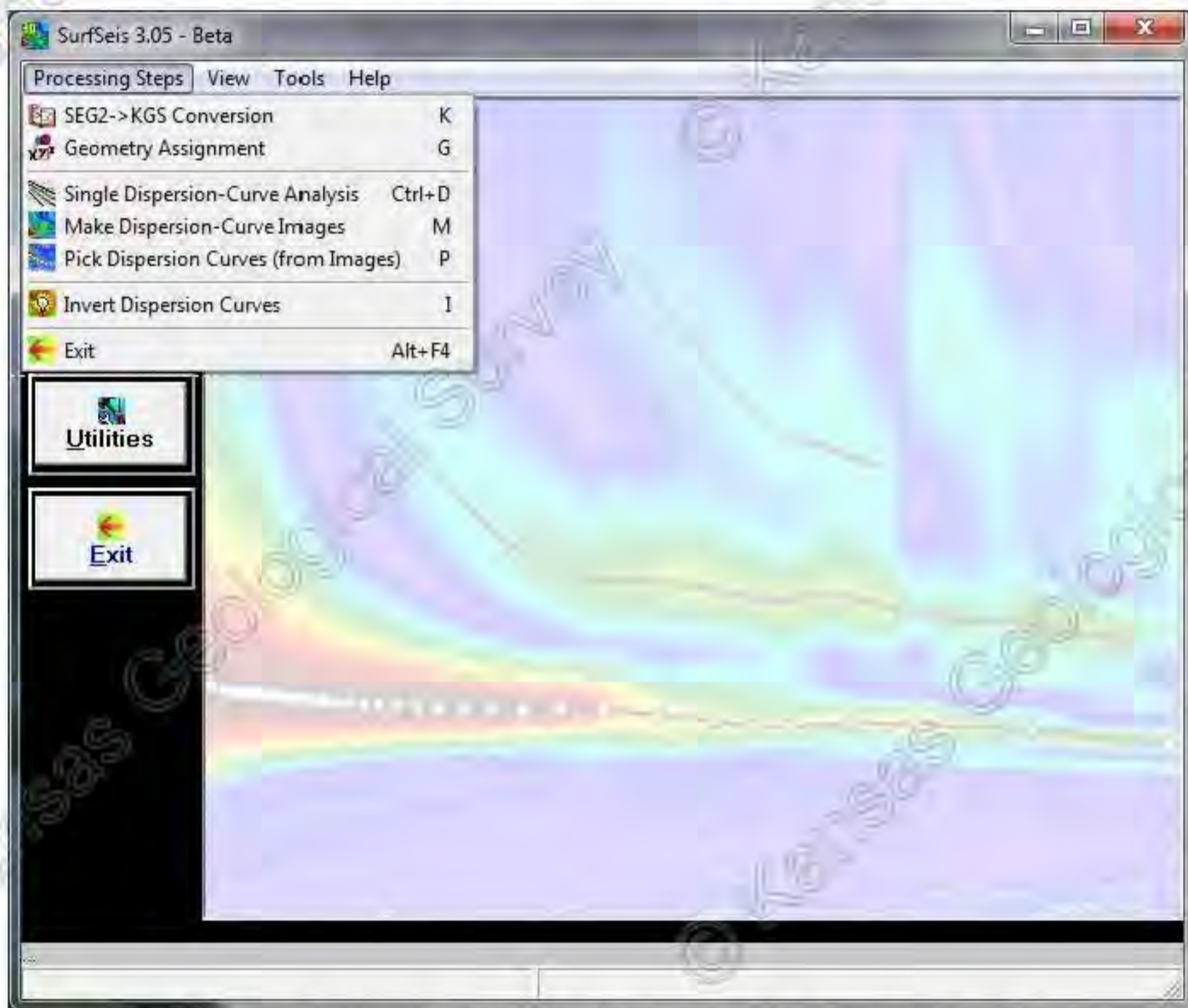


Figure 2. Main window display after selecting “Processing Steps” menu item.

Parts of the functionality and appearance of these forms (windows) may have been improved in comparison to the previous versions of SurfSeis 1.5 described in sections 10.1 and 10.2 of SS12-

10chap15.pdf manual, which can be found in the “Manual” subfolder of the SurfSeis 3.0 application folder (e.g., C:\SurfSeis30\Manual).

The dispersion-curve imaging and estimation step has three menu options:

- “Single Dispersion-Curve Analysis” (“Analysis”, “Dispersion” buttons),
- “Make Dispersion-Curve Images” (“Analysis”, “Multi-Disper.” [former ‘Dispersion 2’] buttons) opening seismic data,
- “Pick Dispersion-Curves (from) Images” (“Analysis”, “Multi-Disper.” [former ‘Dispersion 2’] buttons) opening dispersion-curve image data in KGS format (Figure 2).

The “Single Dispersion-Curve Analysis” window (Figure 3) was improved by adding a menu and modifying some of the forms in comparison to the previous versions of SurfSeis 1.5 described in chapter 3 manual of SS05-3chap15.pdf, which can be found in the “Manual” subfolder of the SurfSeis 3.0 application folder (e.g., C:\SurfSeis30\Manual).

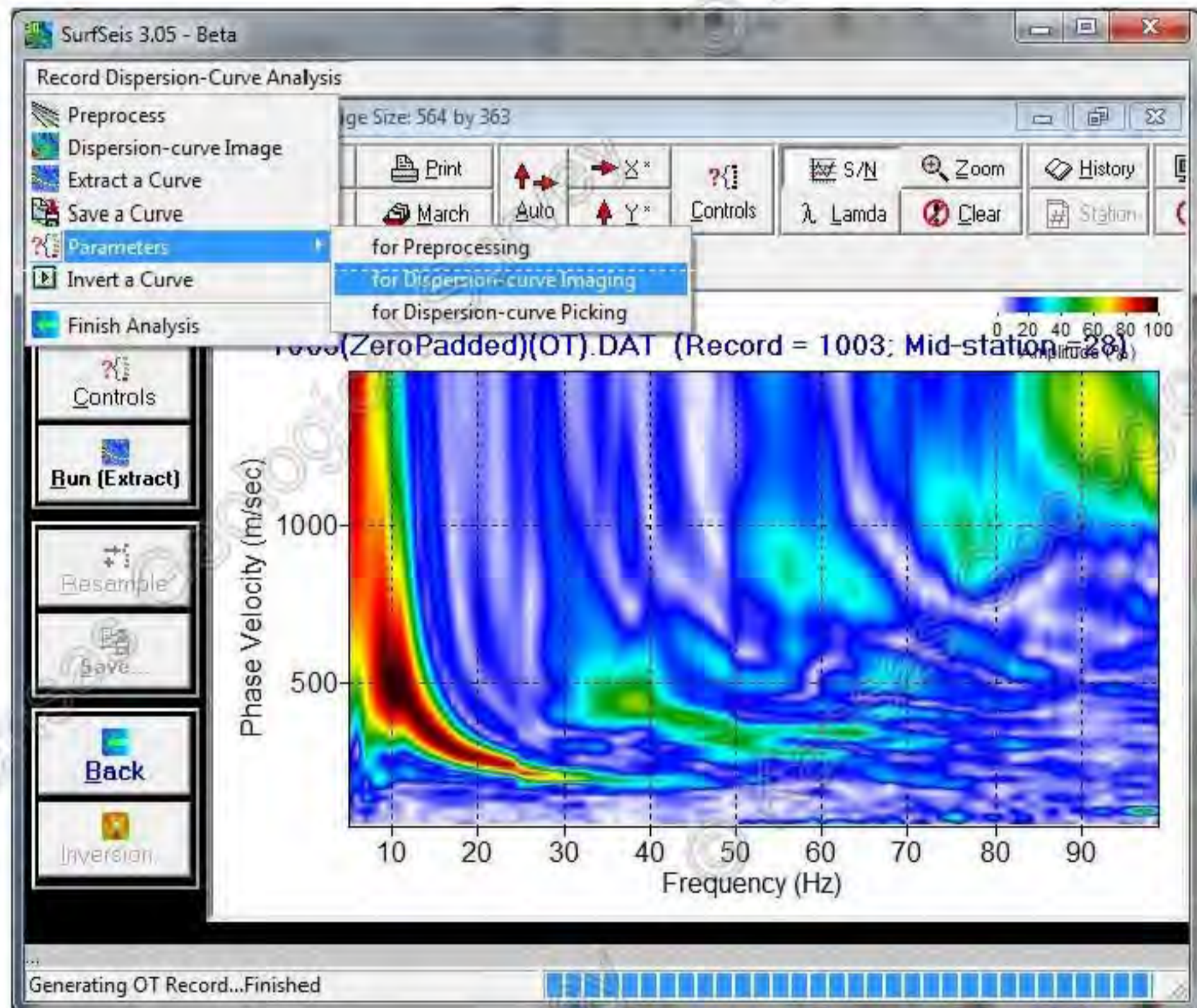


Figure 3. Dispersion curve picking window display after selecting “Single Dispersion-Curve Analysis” from “Processing Steps” menu item.

The “Single Dispersion-Curve Analysis” option is used for processing active seismic data only. The “Back (Finish Analysis)” menu option, the “Back” button, or ‘Alt’+left arrow, restore the main menu.

We have found that the “Single Dispersion-Curve Analysis” approach can be very useful when dealing with a new data set, when there is a need to find the optimal dispersion-curve imaging parameters such as imaging algorithm, contrast, and velocity and frequency ranges. Once these parameters are selected, then it might be more efficient to process dispersion curves in two steps using the other menu options—First, by generating all of the dispersion-curve images from the seismic data into a separate file and then, second, using that file to efficiently interpret and pick (estimate) dispersion-curve mode:

“Make Dispersion-Curve Images” (“Analysis”, “Multi-Disper.” buttons) opening seismic data,
“Pick Dispersion-Curves (from) Images” (“Analysis”, “Multi-Disper.” buttons) opening image data in KGS format (Figure 2).

This pair of menu options is also used to process passive data. Parameter forms have been improved in comparison to those in SurfSeis 2.05 described in Manual20.pdf, which can be found in the “Manual” subfolder of the SurfSeis 3.0 application folder (e.g., C:\SurfSeis30\Manual).

The “View” menu option (Figure 4) groups utilities for viewing different types of data.

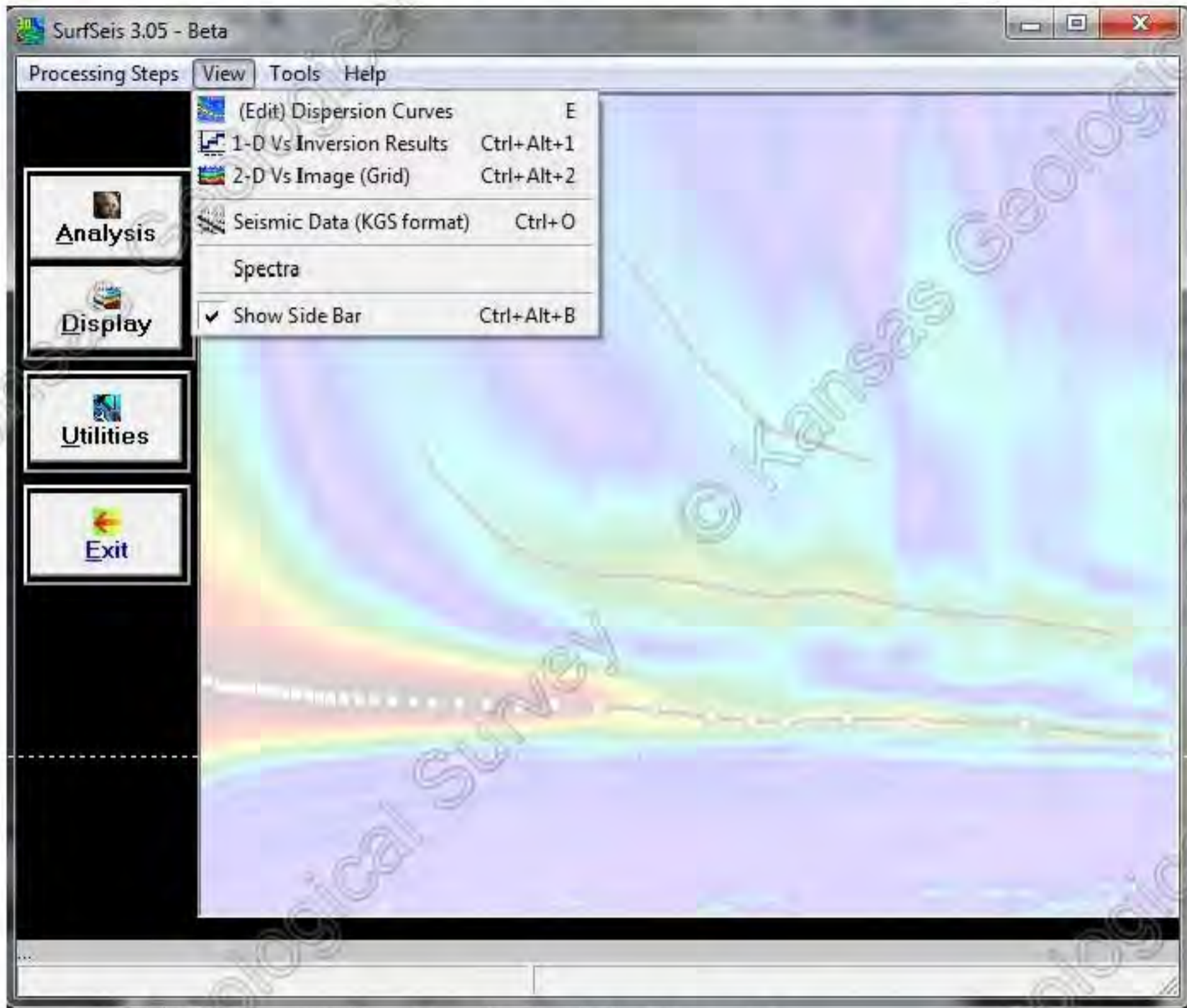


Figure 4. Main window display after selecting “View” menu item.

- | | |
|-----------------------------|---|
| “(Edit) Dispersion-Curve” | (“Display”, “Dispersion” buttons), |
| “1-D Vs Inversion Results” | (“Display”, “Vs 1-D” buttons), |
| “2-D Vs Image” | (“Display”, “Vs 1-D” buttons), |
| “Seismic Data (KGS format)” | (“Display”, “Seismic” buttons), |
| “Spectra” | (“Display”, “Spectra” buttons), |
| “Show Side Bar” | hides/shows the left sidebar that contains the large buttons. |

The “Tools” menu option (Figure 5) groups various additional tools.

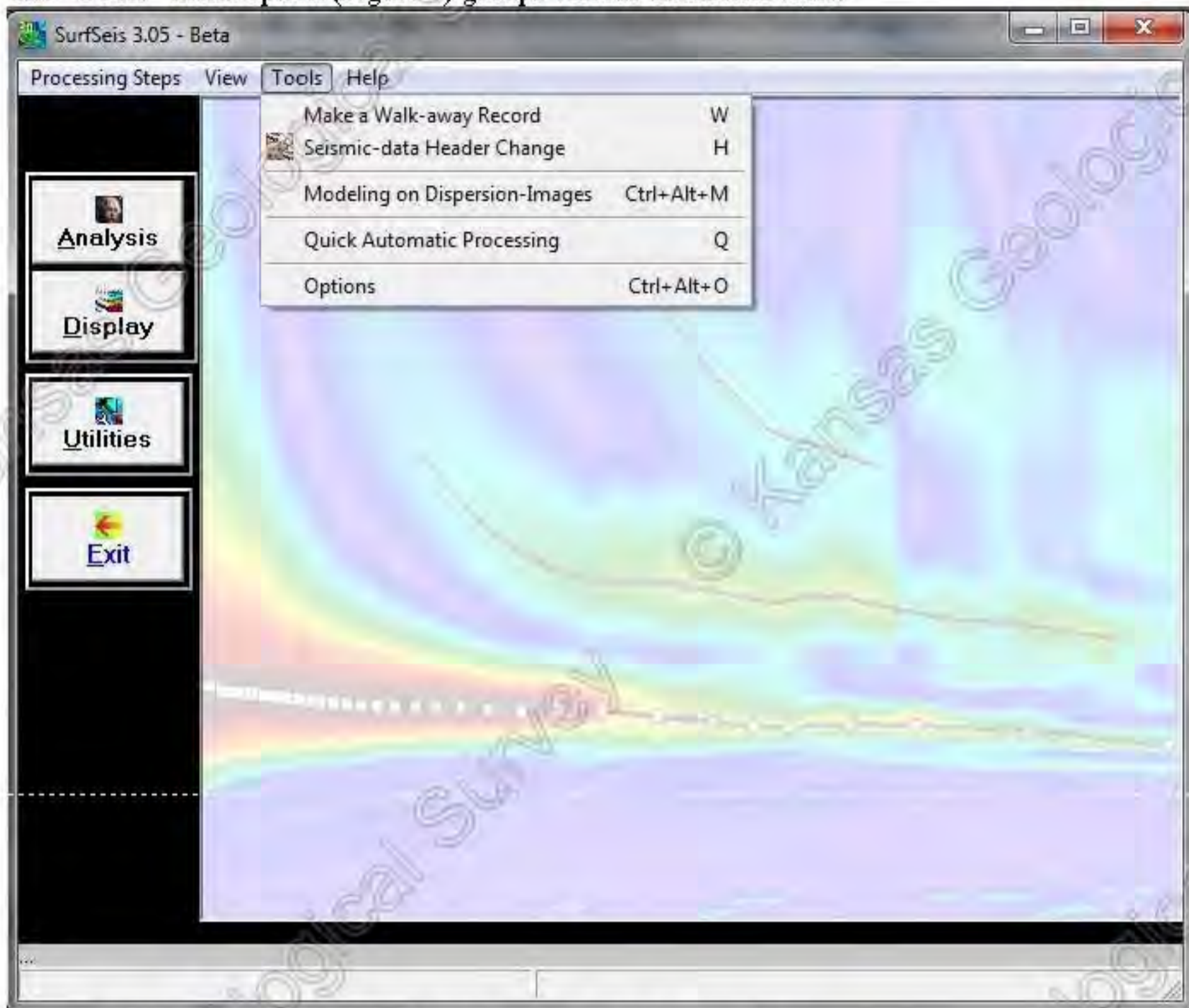


Figure 5. Main window display after selecting “Tools” menu item.

- | | |
|--|--|
| “Make a Walkaway Record” | (“Utility” button, “Edit Data” tab, “Walkaway (Join Records)” tab), |
| “Seismic-data Header Change” | (“Utility” button, “Edit Data” tab, “Header” tab) |
| “Modeling on Dispersion Images” | (“Analysis”, “Inversion” buttons, and opening ‘Overtone (OT) record file (*.dat)’ , which is set by “Files of type” drop box in Open Files dialog). See section 6.2 (p. 30) in Manual20.pdf for more information |
| “Quick Automatic Processing” | (“Analysis”, “Full Auto” buttons) |

The “Dispersion-curve Picking” menu option is displayed (Figure 6) after opening dispersion-curve image data in KGS format after selecting “Processing Steps” and “Pick Dispersion Curves (from) Images” from the menu (Figure 2).

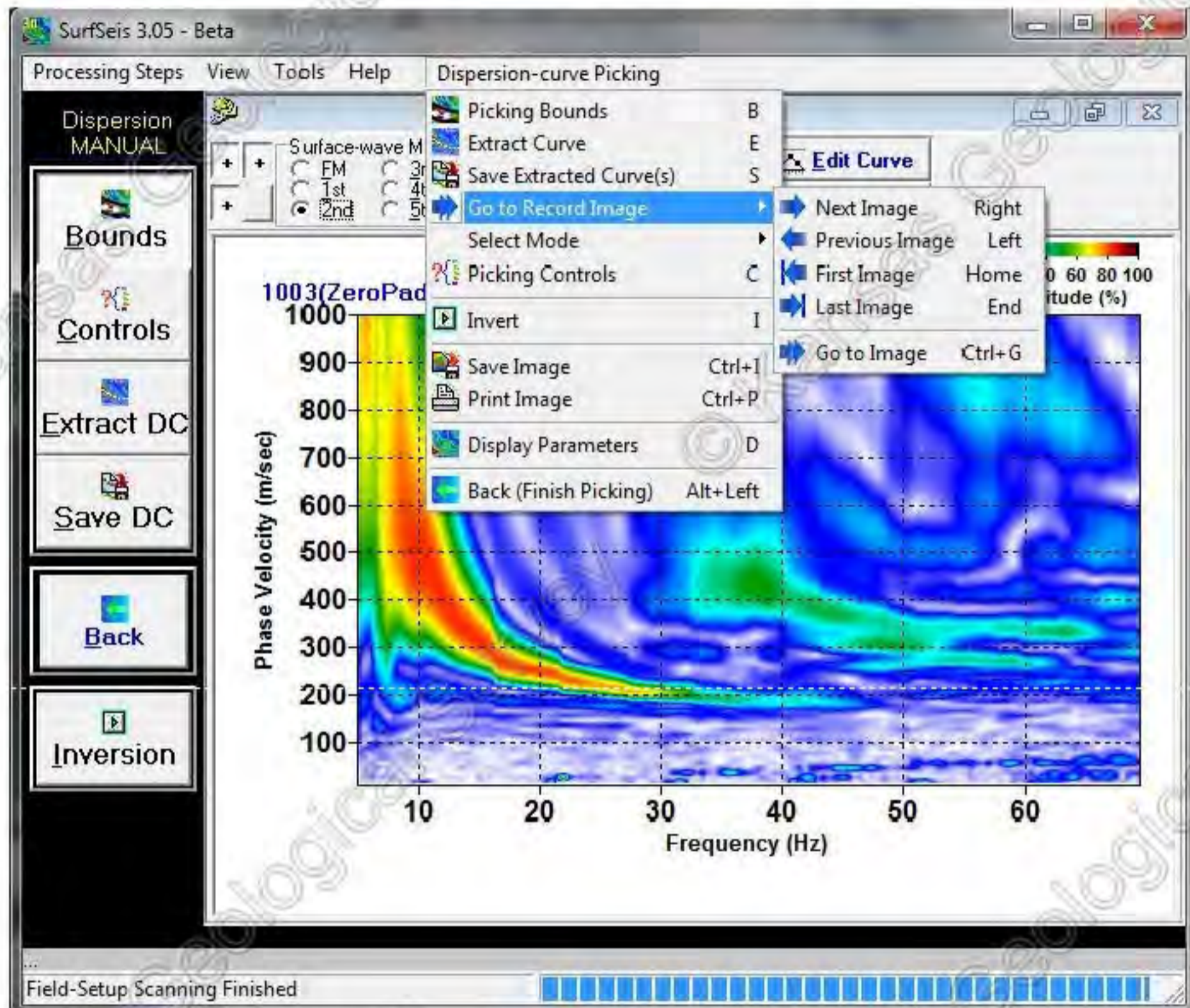


Figure 6. Dispersion-curve picking window display after selecting “Pick Dispersion Curves (from Images)” from “Processing Steps” menu item. Use arrows to quickly go from one record to another.

Choosing “**Invert Dispersion Curves**” (“Analysis”, “Inversion” buttons) from “**Processing Steps**” shows “**Inversion**” menu options only (Figure 7). The “Back (Finish Processing)” menu option, the “Back” button, or ‘Alt’+left arrow, restores the main menu. Some modifications were made to some of the forms in comparison to the previous versions of SurfSeis 1.5 described in chapter 4 of the manual of SS06-4chap15.pdf, which can be found in the “Manual” subfolder of the SurfSeis 3.0 application folder (e.g., C:\SurfSeis30\Manual).

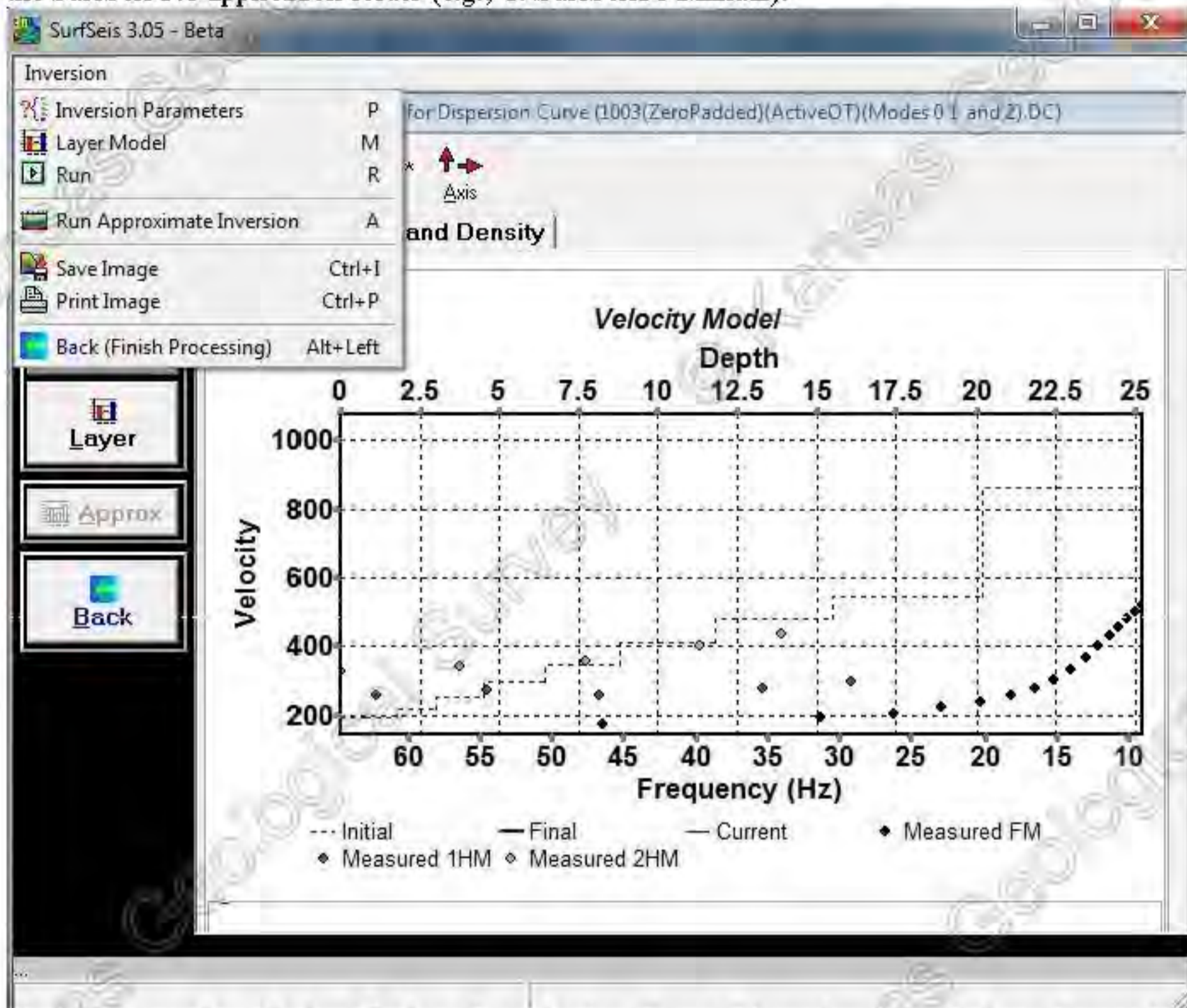


Figure 7. Inversion window display after selecting “Invert Dispersion Curves” from “Processing Steps” menu item.

Chapter 2: Multimode Surface Wave

This new version of SurfSeis (v3) is designed to estimate and invert not only the fundamental mode, as all previous SurfSeis versions, but also higher modes of the surface wave. The usual form (window) for dispersion-curve picking was expanded to reflect mode indication. As well, the dispersion-curve data structure was expanded to retain the mode information.

2.1 Multimode dispersion-curve picking

The dispersion-curve picking is identical to that described in SurfSeis v2.05 manual (section 5.2 from Manual20.pdf). The new element is the “Surface-wave Mode” radio button (Figure 8), which indicates the mode of each dispersion curve picked.

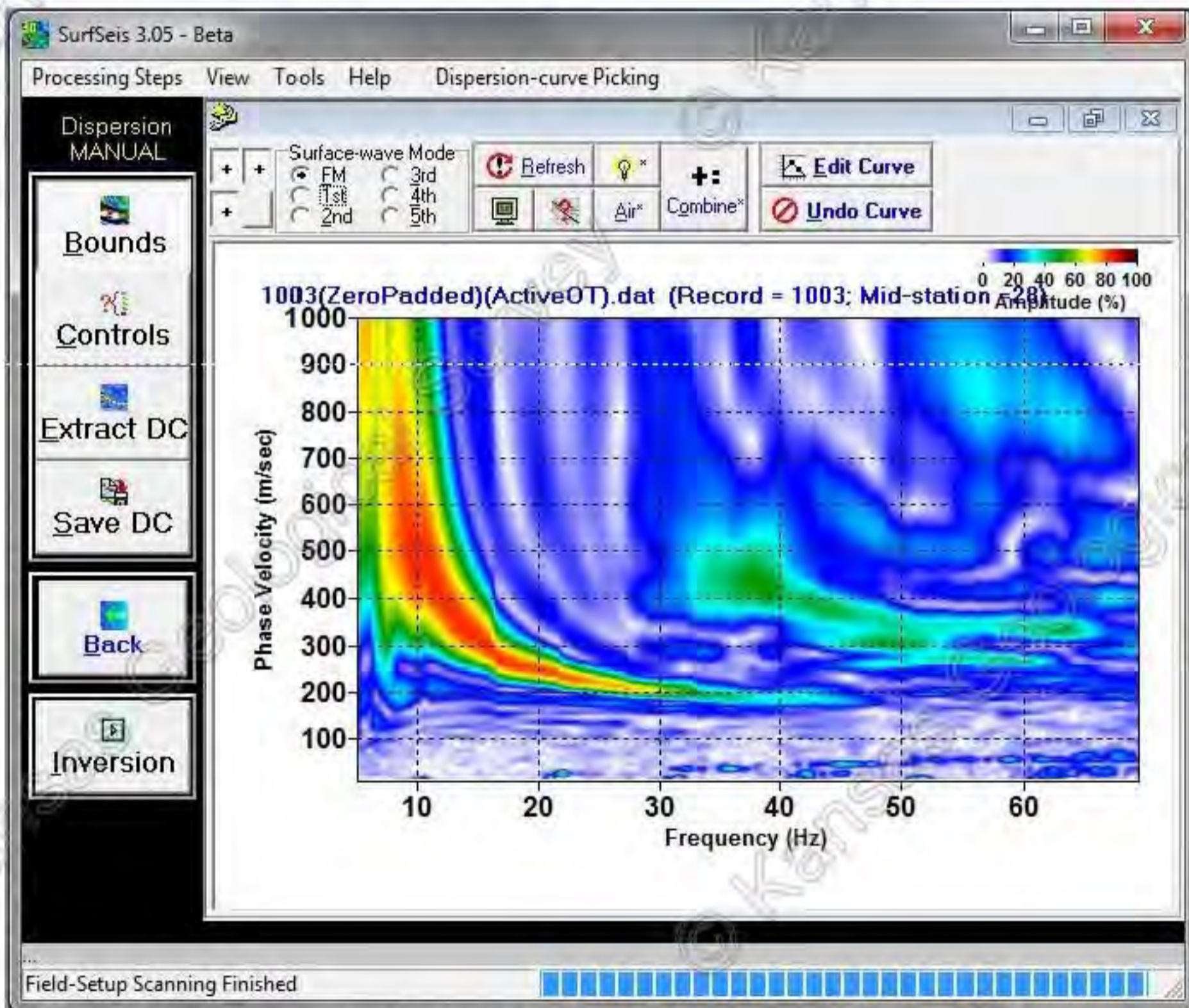


Figure 8. Dispersion-curve picking window display after selecting “Pick Dispersion Curves (from Images)” from “Processing Steps” menu item.

The current dispersion-curve mode can be selected from the menu (Figure 9) or from the keyboard by the letter 'F' (for fundamental mode) or typing a number from 1-5 (for higher modes).

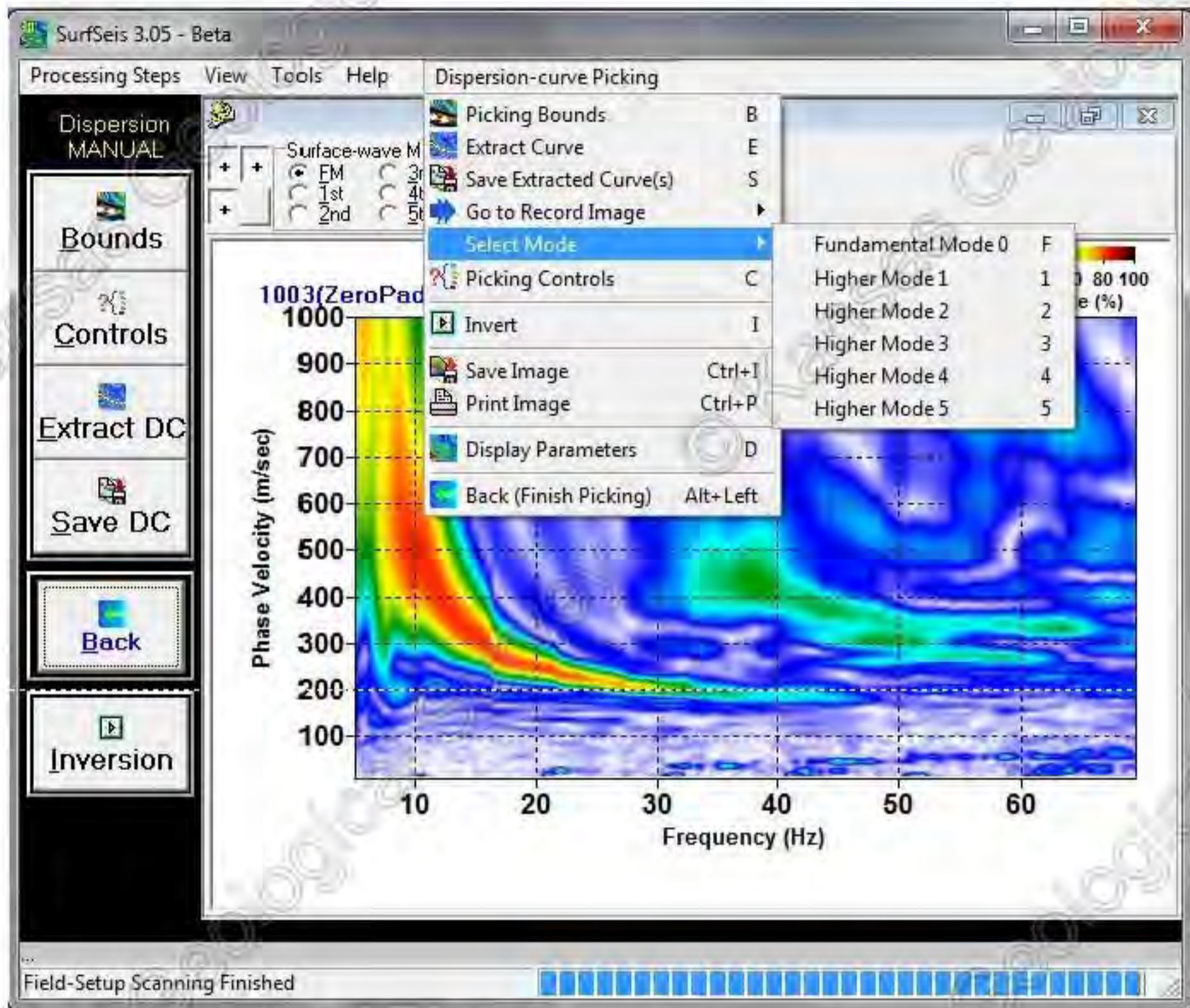


Figure 9. Selecting a surface wave mode from the “Dispersion curve picking” form after selecting “Pick Dispersion Curves (from Images)” from “Processing Steps” menu item.

2.2 Multimode dispersion-curve inversion

Inversion can be started by clicking “Processing Steps” and “Invert Dispersion Curves” from the main menu or just the letter ‘I’ (shortcut).

Multimode dispersion-curve inversion is performed in a manner similar to that in previous versions of SurfSeis. Some modifications were made to the “Inversion Parameters” and “Layer Model” forms in comparison to the previous versions of SurfSeis 1.5 described in chapter 4 of the manual of SS06-4chap15.pdf, which can be found in the “Manual” subfolder of the SurfSeis 3.0 application folder (e.g., C:\SurfSeis30\Manual).

The available inversion parameters now include minimum and maximum velocity range, which can be modified under the “Iteration” tab (Figure 10). This form can be also accessed by choosing the “Iteration Parameters” from the “Inversion” menu (Figure 7), shortcut ‘P’, or the “Controls” button on the left sidebar.

Stopping Criteria

R-M-S Error (in Phase Velocity)

Max. Iteration

Poisson's Ratio or Vp A-Priori Assumptions

Vp fixed (update Poisson's ratio)

Poisson's ratio fixed (update Vp)

Stop automatically when converging

Weighting of Individual Points

Signal-to-Noise Ratio (S/N)

Equal

Inversion-velocity Range

	Initial Model	Scale	For Inversion
Minimum velocity	193	<input type="text" value="0.40"/>	<input type="text" value="77"/>
Maximum velocity	861	<input type="text" value="3.50"/>	<input type="text" value="3012"/>

Synchronize inversion displays

Figure 10. “Inversion Controls” form, “Iteration” tab

The layer parameters table now allows the user to input density information (Figure 11).

Layer Parameters (1003(ZeroPadded)(ActiveOT)(Modes 0 1 and 2).DC)

Layer	Bottom	Thickness	S-Vel (Vs)	P-Vel (Vp)	PDS Ratio	Density (p)
1	0.782	0.782	193	472	0.400	1.550
2	1.759	0.977	195	479	0.400	1.600
3	2.980	1.221	219	536	0.400	1.650
4	4.507	1.527	254	623	0.400	1.700
5	6.416	1.909	296	725	0.400	1.750
6	8.802	2.386	349	856	0.400	1.800
7	11.784	2.982	413	1011	0.400	1.850
8	15.511	3.728	480	1176	0.400	1.900
9	20.171	4.660	545	1334	0.400	1.950
10	Half Space	Infinity	861	2108	0.400	2.000

Controls

of Layers:

Thickness Model

Equal

Variable

User Defined

Figure 11. “Layer Parameters” form, “Iteration” tab

This form (window) can be accessed by choosing “Inversion” and “Layer Model” on the menu, letter ‘M’ (shortcut), or the “Layer” button on the left sidebar.

The ‘Depth conversion ratio’ parameter has been expanded to include the ‘Higher Mode multiplier’ (Figure 12) parameter, which is used to multiply the ‘Depth conversion ratio’ for each additional existing higher mode. This parameter is important if the lowest identifiable surface-wave mode is a higher mode and not the fundamental mode.

Layer model from dispersion curve

Input dispersion curve (*.DC) Browse

1003[ZeroPadded][ActiveDT][Modes 0 1 and 2].DC
E:\3p03\data\Tests\Inversion\RealMModeData\
Number of layers: 10
Depth conversion ratio (%) (0 = Automatic): 0
Higher Mode multiplier: 1.300
Depth to half space (Zmax): 20.171 View/Edit data table

Thickness model
 Equal
 Variable
 User Defined

Output layer model (*.LYR) Browse

1003[ZeroPadded][ActiveDT][Modes 0 1 and 2].LYR
E:\3p03\data\Tests\Inversion\RealMModeData\
OK Cancel

Figure 12. “Layer model from dispersion curve” form.

The above form can be accessed by choosing “Iteration Parameters” from the “Inversion” menu (Figure 7), shortcut ‘P’ (or the “Control” button on the left sidebar), or the “Input Files” tab, and then clicking on the “Layer Model Generation” button (Figure 13).

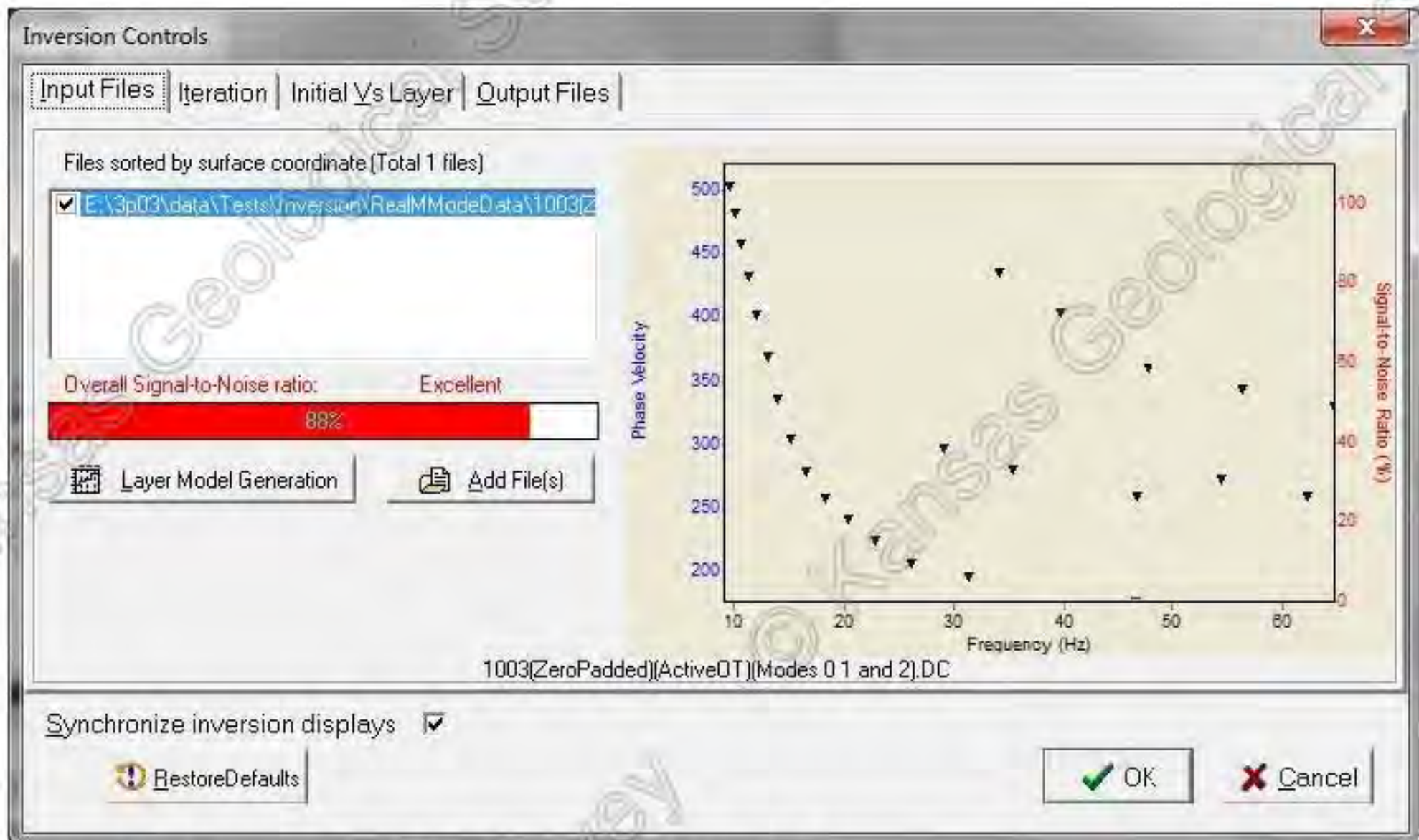


Figure 13. "Inversion Controls" form, "Input Files" tab

Try the letter 'R' on the keyboard (a shortcut) to start the inversion process.

Chapter 3: Hardware License (HL) protection (USB dongle)

Hardware License (HL), aka ‘hardware key’ or ‘USB dongle’ are synonymous term for a hardware device that secures SurfSeis 3 protection and licensing. The hardware license is similar to a USB flash drive (Figure 14) and must be plugged into one of the USB ports on your computer for SurfSeis 3 to run. This new type of protection allows our endusers to install SurfSeis 3 on more than one PC but use it on the one computer where the dongle is installed.



Users can check their available licenses by starting a web browser (e.g., Firefox, Internet Explorer) and typing ‘http://localhost:1947’ in the web address field.

The Admin Control Center is designed to provide our enduser’s system administrator with the means to manage the use of SurfSeis 3 by members of their organization.

The software licensing can be updated using the ‘RUSCodeExchange’ shortcut (application KGS_SentinelRUS.exe), which can be found in the SurfSeis application folder.

Instructions for Using RUSCodeExchange

Since you are using a HL key (hardware-based key), you must connect the key before performing either of the following procedures.

1. Collecting HL Protection Key License-Data Information

You can use the **RUSCodeExchange** shortcut to produce a Customer-to-Vendor (C2V) file containing information on the current status of the licenses in your HL protection key(s). You can then send this file in order to receive a license update.

To retrieve the current license information from a Sentinel HASP protection key:

1. Click the **RUSCodeExchange** shortcut.
2. Click the **Collect Key Status Information** tab.
3. Click **Collect Information**. The **Save key status as** window is displayed.
4. Specify the directory where you want to store the C2V file. Enter a file name and click **Save**.
5. If more than one Sentinel HASP protection key is found on your computer, a list of the keys is displayed. Select the required key, or disconnect the keys that are not required, and click **Refresh**.
6. The C2V file for the Sentinel HASP protection key is generated and saved in the designated location. The file must now be sent for processing to provide you an update.

2. Applying an Update

You can also use the **RUSCodeExchange** shortcut to apply an update to the licenses stored in your HL protection keys.

To update the licenses in HL protection keys:

1. Click the **RUSCodeExchange** shortcut or double-click the Vendor-to-Customer (V2C) file that you received (which contains the update).

Note: We normally send license updates as V2C files. If, however, you have received an update as an executable (.exe), double-click the file and it will automatically launch the **RUSCodeExchange** software.

2. Click the **Apply License Update** tab. (This might be the only tab displayed.)

3. If the **Update file** field is empty, browse to the directory where the update file (.v2c file) is located and select the file.

4. Click **Apply Update** to apply the new license data to the deployed HL protection key.

Any tampering with the software protection can lead to you losing your license. If you lose your license, or if the dongle is damaged, the only way to replace it is to purchase a new copy of SurfSeis 3. Licenses (i.e., dongles) will be replaced only after payment has been received.